HEALTH SURVEILLANCE OF THE PLYMOUTH AREA

Massachusetts Department of Public Health
Center for Health Promotion and
Environmental Disease Prevention

March 16, 1987

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Analyses of health data have been carried out to examine whether there is excess risk of certain adverse health outcomes among residents in the vicinity of the Pilgrim Nuclear Facility located in Plymouth. Five communities were studied because of their proximity to the Pilgrim Plant, area topography, and coastal meteorological conditions. These communities were Duxbury, Kingston, Marshfield, Plymouth, and Scituate. The data revealed no disturbing trends in either the patterns of cancer mortality or in the expression of low birthweight and infant mortality. Radiation monitoring records do not suggest any significant levels of radiation off-site of the Pilgrim plant (the levels of radiation residents of the surrounding communities are potentially exposed to). However, a statistically significant increase in the incidence of cancers of the blood forming organs, primarily leukemia, among males in the five coastal towns has been identified. The number of leukemia cases diagnosed among female residents of the five towns were also higher than expected.

This descriptive study, as the first step of an epidemiologic investigation, has identified the existence of an apparent excess risk of cancer of the blood forming organs, particularly leukemia, among the residents of the five towns. Major gaps exist in our present understanding of the relationship between the occurrence of leukemia and the Pilgrim Nuclear Facility. The second step of an epidemiologic investigation is to determine the likely cause(s) of the excess risk. This data can only be reliably obtained from the cases themselves. Additional resources would be required to collect this detailed information.

This report presents a review of the health and environmental data for the Plymouth area. The data were collected in response to citizen concerns over possible health impacts from the operation of the Pilgrim Nuclear Facility.

SCOPE OF THE PROBLEM

Three analyses have thus far been initiated by the Massachusetts Department of Public Health (MDPH) to examine whether there is an unusual occurrence of selected adverse health outcomes among the residents of five towns - Duxbury, Kingston, Marshfield, Plymouth, and Scituate. These communities were chosen because of their proximity to the Pilgrim Plant, area topography, and coastal meteorological conditions.

Since the basic question related to the possible health effects from ionizing radiation, the kind of radiation associated with x-rays and radioactivity, two of our analyses focused on radiation induced cancers. These cancers are leukemia, multiple myeloma, and cancers of the breast and thyroid. The third analysis focused on adverse reproductive outcomes. All of these health outcomes were chosen because of their known or suspected relationship with exposure to low-dose ionizing radiation, as reported in current medical literature. Information on these health outcomes is routinely collected by MDPH.

Mortality Data

The first analysis reviewed mortality from leukemia and cancers of the breast and thyroid during the period 1969 through 1983. The numbers of

deaths were determined for the five towns, as well as for Plymouth County. The observed numbers of deaths in the five towns were compared to the numbers expected based upon state mortality rates adjusted for age and population differences.

Very few thyroid cancer deaths occurred in the five towns and so no conclusions could be drawn from that data. Tables 1 and 2 show mortality from breast cancer (table 1) and leukemia (table 2) among the residents of Plymouth, the five coastal towns combined (Duxbury, Kingston, Marshfield, Plymouth, and Scituate), and the remaining Plymouth County towns. These data are given for two time periods, 1969-73 and 1979-83. These are the years for which complete data on expected numbers of deaths in the five towns are currently available. The first time period, 1969-73, essentially represents the period before Pilgrim became operational. In both time periods, there was a slightly higher number of breast cancer deaths observed in the five towns than expected (table 1), but these differences were small and statistically not significant. The observed mortality from leukemia in both time periods was also slightly greater than the expected number among the female population, particularly in the town of Plymouth and the five coastal towns combined. Similar excess in leukemia mortality was observed among male residents of the town of Plymouth, but only during 1969-73. However, all these differences between observed and expected mortality were small and statistically not significant. Most importantly, the ratios of observed to expected numbers of leukemia deaths are similar in both time periods. The ratios would be expected to be greater in the later time period if suspected emissions from Pilgrim were resulting in increased cancer mortality. Overall, it appears that compared to the residents of Massachusetts as a whole,

individuals living in the five towns probably did not experience excessive mortality from these cancers.

Appendix I shows the numbers of observed and expected deaths from leukemia among the residents of all towns within approximately twenty miles of the Pilgrim Facility during the two time periods. This data is presented to illustrate the number of deaths for each town in the region. These towns represent a large geographic area where the potential for exposure to emissions from a point source such as Pilgrim would differ greatly among the residents. Therefore, an analysis of the area as a whole to explore any possible relationship with Pilgrim emissions would be inappropriate.

Incidence Data

Cancer incidence, newly diagnosed cases, was reviewed in the second analysis. Incidence data were obtained from the Massachusetts Cancer Registry, which has collected information on all cancers diagnosed in Massachusetts since 1982. Computerized data were available for the years 1982-84 and all cases diagnosed in those years were used in this analysis. As in the first analysis, the numbers of observed cases were compared with the corresponding numbers of expected cases. Cancer incidence rates for the whole of Massachusetts were used to estimate the expected numbers.

There was no statistically significant excess of breast or thyroid cancer incidence among the residents of Plymouth or of the five towns combined. It should be noted, however, that an excess would not be expected from 1982-84 incidence data even if there was sufficient exposure from radiation to cause cancer. This is because it is estimated that these two

cancers take approximately fifteen years to develop after they are initiated by some causal factor like radiation. By 1984, the most recent year for which cancer incidence data is currently available, the Pilgrim Plant had been operational for less than twelve years. Therefore, it will be at least three years, and likely longer, before MDPH will have the cancer data to properly assess any possible relationship between Pilgrim emissions and breast and thyroid cancer.

Because of reporting practices of the Cancer Registry, all cancers of the hematopoietic and reticuloendothelial systems (cancers of the blood forming organs), which include leukemia as well as multiple myeloma and some very rare forms of cancer, were reviewed as part of the initial incidence analysis. Table 3 shows the incidence of cancers of the blood forming organs among the residents of Plymouth and the five coastal towns combined, diagnosed between 1982 and 1984. The apparent excess in observed incidence in Plymouth is statistically not significant. But when the cancers are reviewed for the five towns combined, the number of new cases diagnosed among males is significantly (statistically) greater than expected based upon state rates. The number of these cancers among females was also elevated, but the excess was not statistically significant.

Figures 1 and 2 show the distribution of hematopoietic and reticuloendothelial cancer incident cases (cancers of the blood forming organs) diagnosed in 1982 through 1984 in the five towns. They appear to be distributed throughout the census tracts within the towns.

As stated above, the cancers of the hematopoietic and reticuloendothelial system are comprised of several types of related cancers. The two

principal types are leukemia and multiple myeloma. Leukemia itself is characterized by several different subtypes. The major subtypes are chronic lymphocytic, acute lymphocytic, acute nonlymphocytic, and chronic myelogenous leukemias. Each of these cancer subtypes can be caused by certain environmental exposures. But, not all of the same environmental causes are related to each subtype of leukemia. For example, exposure to ionizing radiation does not appear to be associated with chronic lymphocytic leukemia (CLL) but is associated with the development of other types of leukemia and of multiple myeloma. With this in mind, the analysis of incidence was further focused to examine all hematopoietic and reticuloendothelial cancers, excluding CLL. Results were analyzed only for the five towns combined because of the small number of cases within each town.

Table 4a illustrates the results of this analysis for the five towns combined. The number of cases observed among males between 1982 and 1984 was again observed to be significantly (statistically) in excess over the number expected in the five towns. The number of female cases was also elevated but not statistically different from the number expected. In other words, there is a reasonable probability that the differences between observed and expected numbers among females are due to chance alone.

To further refine the analysis, the latency periods was reviewed for each of the cancer types and subtypes. Latency period is the length of time between initial exposure to the potential cause(s) of the cancer and the time when the cancer first becomes detectable (diagnosis). The latency of multiple myeloma is at least 15 years. The subtypes of leukemia have varying latent periods (2-20 years), frequently dependent upon age at

exposure. Since the latency of multiple myeloma is likely greater than the number of years Pilgrim has been operational, leukemia is the radiation-sensitive cancer outcome that would have the greatest probability of showing an association, using current cancer statistics, with any past Pilgrim emissions. Myelogenous leukemias are the leukemias most sensitive to induction by radiation.

Tables 4b through 4d show the number of observed and expected leukemias for this more refined analysis. Ten hospitals have been identified as the place of diagnosis for the 1982-84 leukemia cases. Four were in Boston and the remaining six hospitals represent the major health care centers in southeastern Massachusetts. Among males the incidence of each leukemia group was consistently elevated. Each elevation is statistically significant. The incidence of all leukemia and the subtype myelogenous leukemia among females was slightly elevated, but the numbers of observed cases were not statistically different from the number expected based upon state incidence figures.

One explanation for why the elevation is higher in males than females may be that males are at greater risk for exposure to the factor(s) that cause leukemia in the five towns. Epidemiologic research has shown that the induction of leukemia has been associated with a number of different factors, including chemicals, certain medical drugs, and diagnostic/therapeutic radiation. Occupational exposures that are known to cause leukemia, such as chemicals and radiation, are well-documented. It may be that males in the five towns had a greater opportunity for these occupational exposures, resulting in the higher elevations of leukemia. Another explanation may be that males had a greater potential for exposure to air emissions from Pilgrim because of the proximity to the

plant of their residence or place of employment. Without in depth knowledge of the type of work the cases performed, where they worked, and where they lived, it is not possible to determine the differences in potential for exposure between males and females to either occupational risk factors for leukemia or air emissions from Pilgrim.

Leukemia mortality was not significantly different from that expected, whereas leukemia incidence appears to be elevated, particularly among males. There are several possible explanations for these inconsistent findings.

One is that survival after the diagnosis of leukemia may be better in the five town area than in the state as a whole. This may be due to earlier diagnosis, better health care, or better utilization of health care facilities. With early diagnosis and treatment, an individual's cancer can frequently be controlled or cured. As a result, the individual may ultimately die from some cause unrelated to the cancer and thereby not be recorded as a cancer mortality statistic. Incidence would reflect all the cancers diagnosed but mortality, therefore, would reflect only those cancers for which the cause of death happened to be cancer.

Another explanation may be that the increase in the risk of leukemia is only recent and, therefore, would only be reflected in current incidence statistics. Most cancer deaths occur several years after diagnosis and so 1985 mortality would, for example, include many cases likely diagnosed before 1982. Incidence provides the best indication of current elevated risks of cancer.

A third explanation may be that the apparent elevation in leukemia

incidence is due to a chance fluctuation in the observed numbers. Numbers of observed cases characteristically increase and decrease from year to year. Therefore, these fluctuations are possibly unrelated to any general environmental exposures such as air pollution or contaminated drinking water. Small numbers, in particular, are frequently susceptible to significant fluctuations from year to year that can result in misleading differences when compared with expected numbers which are based on larger, more stable numbers.

Appendix II shows the numbers of incident cancers of the hematopoietic and reticuloendothelial system (cancers of the blood forming organs) in towns within twenty miles of the Pilgrim plant. As with the mortality data shown in Appendix I, it would be inappropriate to analyze these towns as a group because the potential for exposure to adverse environmental exposures would vary greatly from town to town.

Adverse Reproductive Outcomes

The third analysis dealt with two adverse reproductive outcomes in the Plymouth area, infant mortality and low birthweight. Adverse reproductive outcomes often are sensitive though nonspecific indicators of environmental problems. Figures 3 and 4 show annual infant mortality rates and prevalence of low birthweight among live births in the town of Plymouth, Plymouth County, and Massachusetts from 1969 to 1984. (Infant mortality is defined as death within the first year of life; and low birthweight is defined as birthweight below 2500 grams.) There was an obvious, gradual decline in both infant mortality and low birthweight rates in each of the three geographical areas before and after the Pilgrim plant was operational. The year-to-year fluctuations in the rates,

particularly for the town of Plymouth, show the susceptibility to variation of rates derived from very small numbers of events. For example, the 25 percent increase in infant mortality observed in the town of Plymouth from 1981 to 1982 is accounted for by an increase in the number of infant deaths from four to five. Without these short-term fluctuations, the rates for Plymouth Town and Plymouth County appear to have been lower than the rates for the State as a whole.

Environmental Data

In addition to health studies, MDPH has reviewed radiation data regarding the Pilgrim Nuclear Facility. Monitoring of ionizing radiation in the vicinity of the Pilgrim Facility has been ongoing since the plant first became operational in 1972. This monitoring is carried out by MDPH and the U.S. Nuclear Regulatory Commission (NRC), as well as Boston Edison. Measurements in the town of Plymouth have been compared with measurements from monitoring stations outside the Plymouth area, and suggest that radiation levels off-site around the Pilgrim plant have been at or below the levels measured elsewhere in the state.

Additionally, the U.S. Environmental Protection Agency (EPA) and the International Atomic Energy Agency (IAEA) have reported on background radiation levels for Massachusetts. Background radiation represents the amount of ionizing radiation that is normally present in the environment. The level for Massachusetts is reported as an average of approximately 13 microroentgens per hour. Except for one location on the Pilgrim site near the stack, radiation levels in Plymouth have essentially been at or below background levels for the state.

Additional environmental radiation data are currently under review by MDPH. These include radiation measurement data from lake sediment, pasteurized milk, and drinking water. Data from on-site radiation monitoring (particularly emissions at the stack), will also be reviewed to assess the levels of on-site radiation emissions over time.

Health data reviewed thus far indicate an elevation in the incidence of cancers of the blood forming organs, particularly of leukemia, among the residents of the five coastal communities studied. This elevation is statistically significant among males. No elevation was found for cancers of the breast and thyroid, though none would have been expected even if there had been sufficient radiation exposure to induce these types of cancer. This is because breast and thyroid cancers generally take more years to develop after they are initiated by some causal factor like radiation than the number of years the Pilgrim plant has been operational.

The biological significance of the incidence of leukemia in relation to possible radiation emissions from the Pilgrim plant cannot be fully determined from the available data. No clear pattern or gradient of cancers around the plant is apparent. Generally, if some point source, such as Pilgrim, is suspected of emitting pollutants then those at greatest risk of exposure would be those living closest to the plant. Those individuals with the greatest exposure would also be those with the greatest risk of disease caused by that exposure. This is because as dose of exposure increases, so usually does the frequency of disease (dose-response relationship). Therefore, one might expect to see more leukemia among those living closest to Pilgrim and less as the distance from Pilgrim increases, if emissions are causing leukemia. This was not observed. It should be noted, though, that many of the surrounding towns are sparsely populated and, therefore, a gradient might be difficult to identify. Furthermore, if the ability of radiation to induce leukemia is

approximately the same for widely differing doses of exposure, then a gradient might again not be evident. Furthermore, the off-site radiation measurement data reviewed so far (the levels of radiation residents of the surrounding communities are exposed to) are not consistent with the development of adverse health outcomes, based upon current medical knowledge.

Interpretation of the health data currently known for the Plymouth area requires a certain understanding of the limitations and value of the data before definitive conclusions can be drawn. The Commonwealth has mandated the reporting of all new cases of cancer since 1982. On the average, there is a six month lag between diagnosis and the report arriving at the Massachusetts Cancer Registry, located at and administered by MDPH. The reporting hospital is required to report any changes made in the diagnosis of cases previously reported to the Registry.

Additionally, the Cancer Registry regularly conducts quality control checks. This process includes checks on the reported diagnosis, as well as the completeness of case ascertainment. These quality control procedures are in line with the procedures used by cancer registries in other states and those supported by the National Cancer Institute, and assure the validity of the cancer incidence data.

Any changes made in the Registry data as a result of these processes often result in the revision of incidence rates for specific cancers and for specific towns. This has occurred since August 1986 when the Registry learned that a female leukemia case in Plymouth had mistakenly been reported by a hospital as a male resident of Scituate. The correction of this error altered the number of hematopoietic and reticuloendothelial

cancers in the five towns from 32 males and 20 females to 31 males and 21 females.

The Cancer Registry data are routinely used for the purpose of surveillance. This involves comparing the incidence of specific cancer(s) between communities or between communities and the state. The comparisons are often complicated by year-to-year fluctuations in the rates due to the small numbers of reported cases and the small population size of many communities. Consequently, there is often little statistical confidence in the observed differences between the incidence rates. Additionally, current cancer incidence data are of limited use for assessing time trends (to indicate increasing or decreasing incidence rates) in a particular community or region because incidence data are presently available for only three years (1982-1984).

Even with stable rates and large populations, descriptive analyses, such as that presented in this report, only provide information as to the possible existence of a problem and not to the cause(s) of the problem. Regarding leukemia in the Plymouth area, a broad spectrum of risk factors may have contributed to the observed incidence.

Occupational exposures, particularly among those who work in the rubber and leather industries, have been implicated in epidemiologic research as risk factors for leukemia. Exposure to benzene, for example, is a documented risk factor for leukemia. Use of certain cytotoxic drugs such as chloramphenicol, and radiation received in the course of diagnostic tests or treatment are also considered as possible causes of leukemia. The past residential histories of cancer cases is also of importance in order to determine if there is a relationship between previous residence

of a case and proximity to the Pilgrim plant. Proximity to the Pilgrim plant acts as a proxy measure of the potential for exposure and the intensity of that exposure. That is, the closer an individual lives to the plant, the greater the potential of exposure. Similarly, the length of residence acts as a proxy measure for duration of exposure.

Available information on these important factors is presently limited or nonexistent. It is, therefore, not yet possible to establish whether there is a cause and effect relationship between the observed leukemia incidence and exposure to possible radiation emissions from the Pilgrim plant.

CONCLUSION

These analyses of health data have revealed no disturbing trends in either the patterns of cancer mortality or in the expression of low birthweight and infant mortality. Presently, radiation monitoring records do not suggest any significant levels of radiation off-site of the Pilgrim plant (the levels of radiation residents of the surrounding communities are potentially exposed to). However, a statistically significant increase in the incidence of cancers of the blood forming organs, primarily leukemia, among males in the five coastal towns has been identified. The number of leukemia cases diagnosed among female residents of the five towns were also higher but not significantly higher than expected.

This review has established that there is an apparent excess risk of leukemia incidence in the five towns combined. But limitations in the data available for this investigation preclude an assessment of the magnitude of public risk from exposure to air emissions from the Pilgrim Nuclear Facility. Major gaps exist in our present understanding of the relationship of the nuclear facility with the health status of the residents of Plymouth and surrounding communities. The major gaps include a full characterization of occupational history, residential history, and medical history concerning the leukemia cases.

In response to concerns regarding the elevated incidence in the communities investigated, MDPH has considered several approaches to a comprehensive study of the cancer incidence. The objective of the study MDPH is committed to conduct will be to overcome the limitations of the present health data. This would be accomplished through the collection of

information regarding possible causes of leukemia, including emissions from the Pilgrim plant, by means of interviews with cases. The study will be designed to include a sufficient number of cases and explore possible causes of the observed excess of leukemia in these communities. Such a study will require resources that are currently unavailable to MDPH.

FIGURE 1

Number of cases of leukemia, multiple myeloma, and other rare cancers of the blood forming organs diagnosed in 1982-84 among the residents of Plymouth, by census tracts

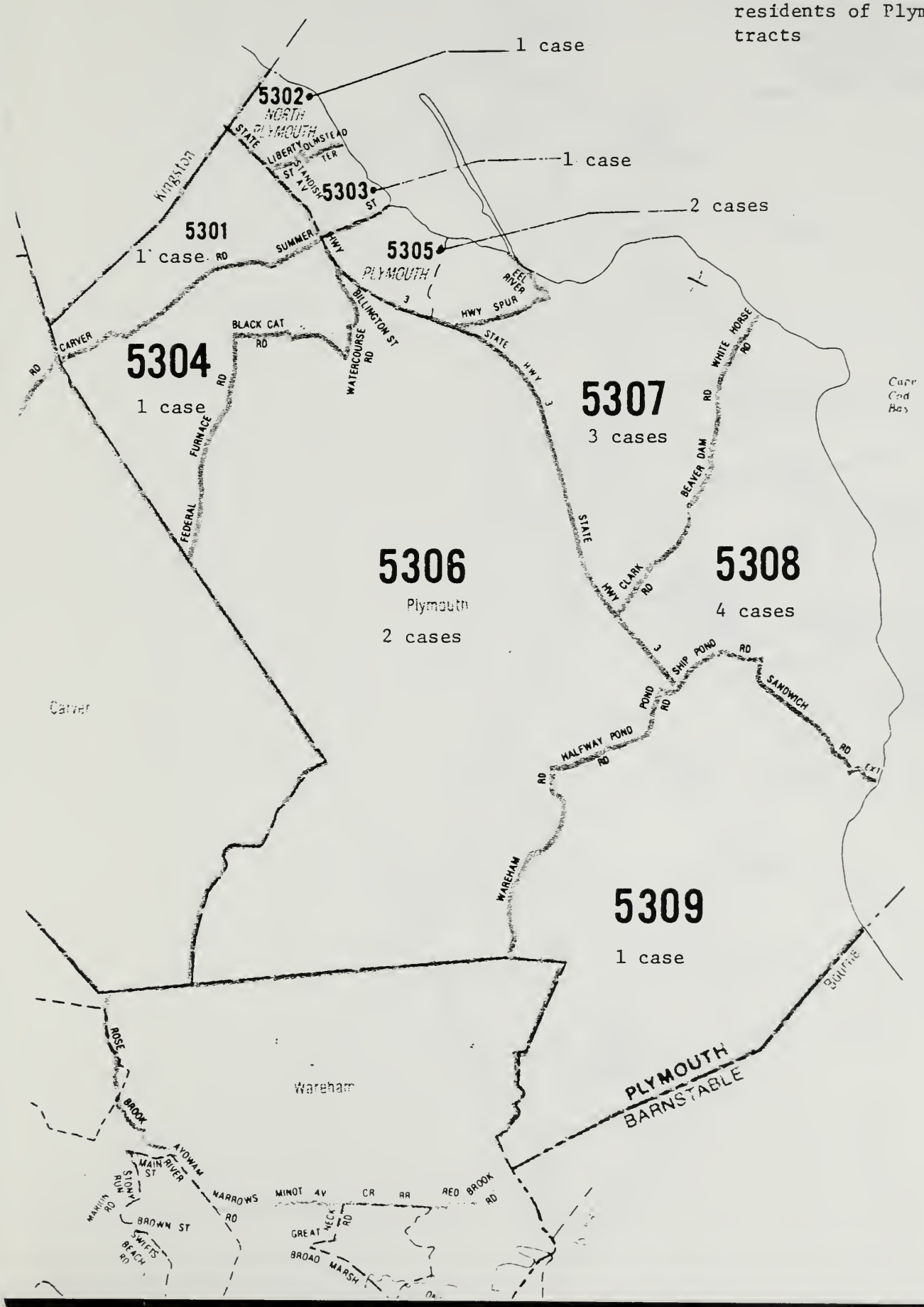

FIGURE 2

Number of cases of leukemia, multiple myeloma, and other rare cancers of the blood forming organs diagnosed in 1982-84 among the residents of Duxbury, Kingston, Marshfield, and Scituate, by census tracts

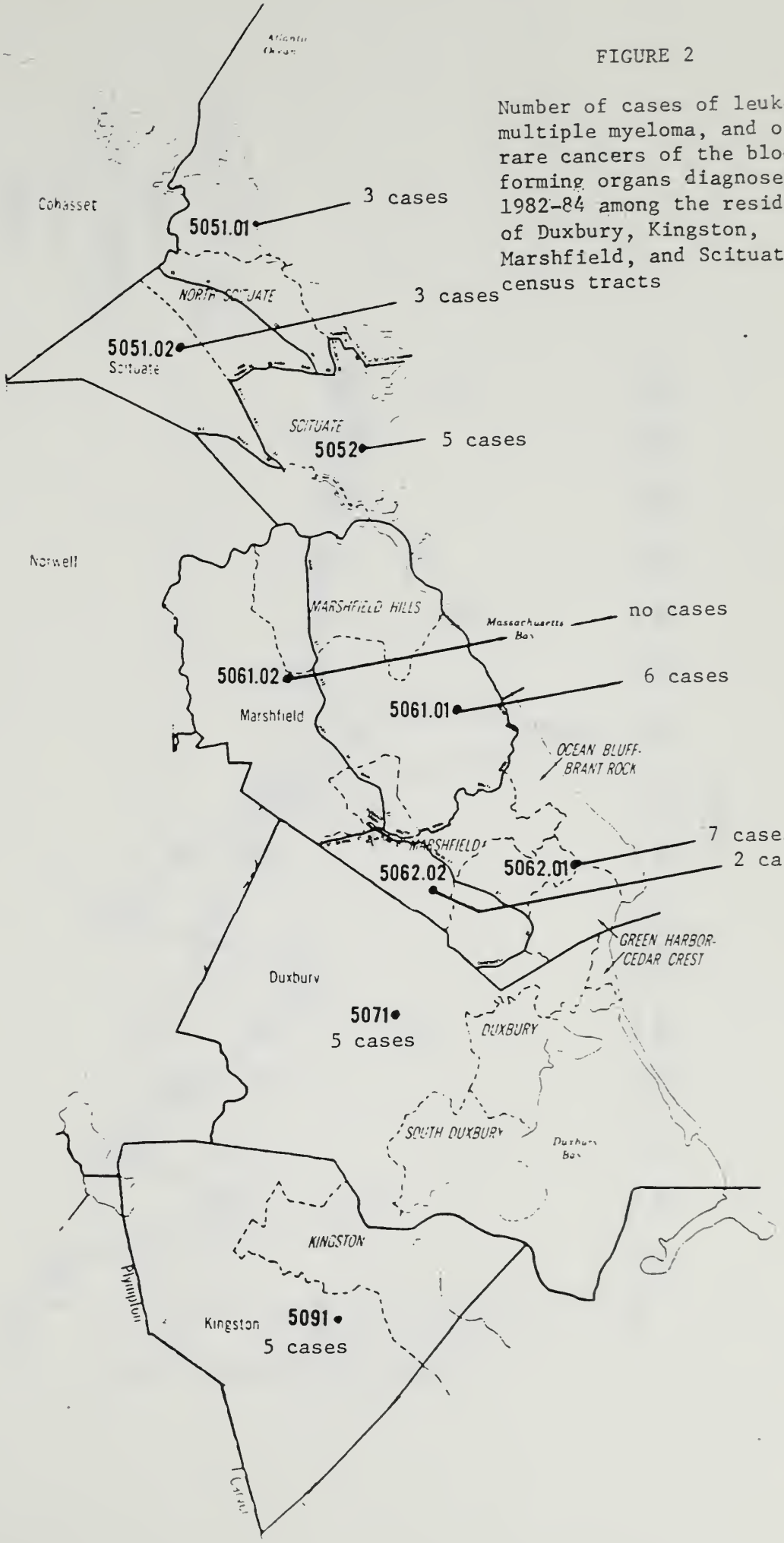

FIGURE 3

INFANT MORTALITY RATE
IN PLYMOUTH, PLYMOUTH COUNTY, AND MASSACHUSETTS
1969 - 1984

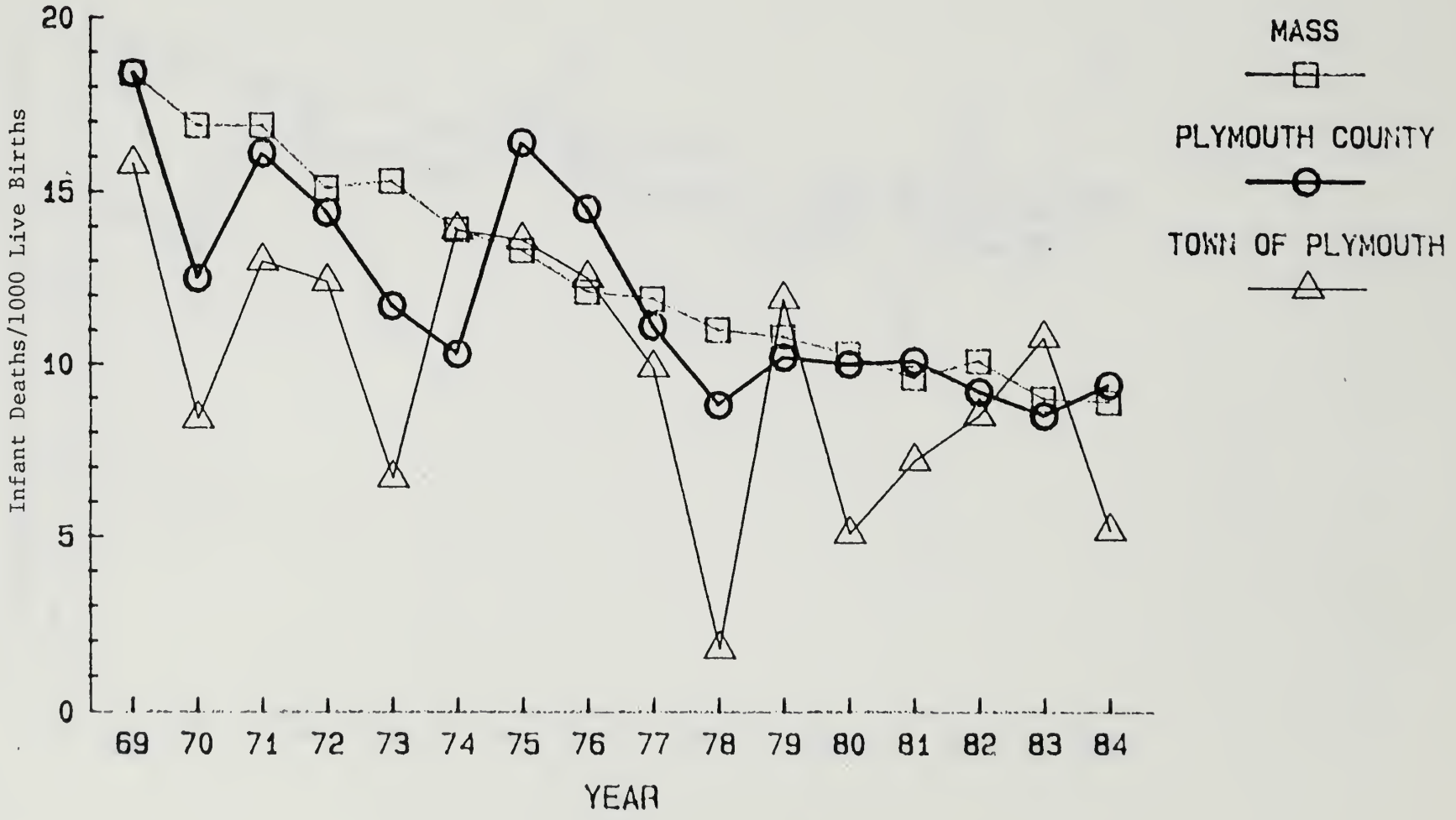

FIGURE 4

PERCENT OF LOW BIRTHWEIGHT IN PLYMOUTH, PLYMOUTH COUNTY, AND MASSACHUSETTS 1969 - 1984

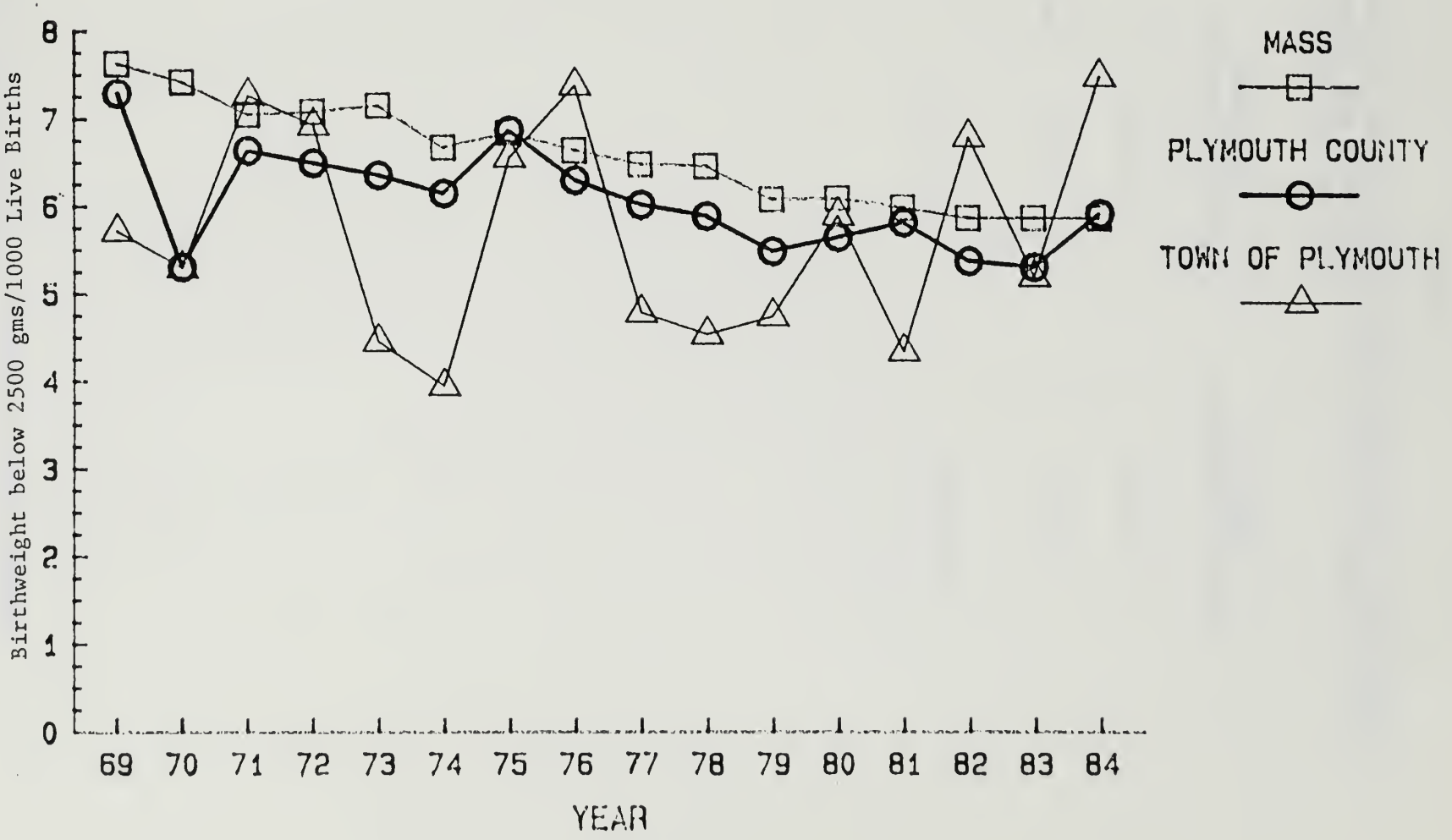

TABLE 1

The numbers of observed and expected breast cancer deaths among female residents of Plymouth, the five coastal towns, and the remaining towns of Plymouth county for two time periods.

	1969-1973 Observed/Expected	1979-1983 Observed/Expected
Plymouth	16/21.5	29/33.2
Five Towns Combined	56/54.9	84/79.6
Rest of Plymouth County	214/219.6	284/269.8

Source: Division of Health Statistics & Research, Massachusetts Department of Public Health

TABLE 2

The numbers of observed and expected leukemia deaths among the residents of Plymouth, the five coastal towns, and the remaining towns of Plymouth county for two time periods.

		1969-1973 Observed/Expected	1979-1983 Observed/Expected
Plymouth	Males	6/4.3	5/6.9
	Females	5/3.6	7/5.9
Five Towns Combined	Males	8/11.7	16/16.3
	Females	12/9.4	16/13.8
Rest of Plymouth County	Males	43/47.3	44/54.7
	Females	47/37.4	43/47.1

Source: Division of Health Statistics & Research, Massachusetts Department of Public Health

Table 3

The numbers of observed and expected incident cases of cancers of the hematopoietic and reticuloendothelial system diagnosed among the residents of Plymouth and the five coastal towns between 1982 and 1984.

		Observed*	Expected
Plymouth	Males	10	7.5
	Females	7	6.6
Five Towns Combined	Males	31	18.1**
	Females	21	15.2

* Observed numbers reflect corrections reported by hospitals since August, 1986

** Statistically significant difference ($p<.05$)

Source: Division of Health Statistics & Research, Massachusetts Department of Public Health

TABLE 4a

The numbers of observed and expected incident cancers of the hematopoietic and reticuloendothelial systems, excluding chronic lymphocytic leukemia (CLL), diagnosed among the residents of the five coastal towns between 1982 and 1984.

	Observed	Expected
Males	28	14.8*
Females	17	12.6

TABLE 4b

The numbers of observed and expected incident cases of leukemia, all subtypes, diagnosed among the residents of the five coastal towns between 1982 and 1984.

	Observed	Expected
Males	22	12.1*
Females	12	9.3

TABLE 4c

The numbers of observed and expected incident cases of leukemia, excluding chronic lymphocytic leukemia (CLL), diagnosed among the residents of the five coastal towns between 1982 and 1984.

	Observed	Expected
Males	19	9.4*
Females	8	7.6

TABLE 4d

The numbers of observed and expected incident cases of myelogenous leukemia diagnosed among the residents of the five coastal towns between 1982 and 1984.

	Observed	Expected
Males	13	5.2*
Females	6	4.8

* statistically significant difference ($p<.05$)

Source: Division of Health Statistics & Research, Massachusetts Department of Public Health

Appendix I

Observed and expected numbers of deaths from leukemia among the residents of selected towns in Southeastern Massachusetts, 1969-1973 and 1979-1983

	1969 - 1973		1979 - 1983	
	Observed	Expected	Observed	Expected
Barnstable				
Males	3	4.9	11	8.0
Females	3	3.8	12	7.0
Bourne				
Males	4	2.1	4	2.9
Females	5	1.7	1	2.1
Bridgewater				
Males	2	2.2	0	2.6
Females	0	1.4	0	2.1
Carver				
Males	0	0.5	2	1.1
Females	1	0.3	1	0.7
Duxbury				
Males	1	1.5	2	1.9
Females	0	1.1	2	1.5
East Bridgewater				
Males	0	1.5	1	1.6
Females	0	1.1	1	1.4
Halifax				
Males	0	0.5	1	1.1
Females	0	0.4	1	0.8
Hanover				
Males	1	1.3	1	1.5
Females	1	1.0	0	1.2
Hanson				
Males	0	1.2	0	1.3
Females	1	0.8	2	1.0
Kingston				
Males	0	1.1	1	1.4
Females	2	0.8	3	1.1
Marion				
Males	1	0.7	1	0.9
Females	0	0.5	2	0.6
Marshfield				
Males	0	2.3	5	3.1
Females	3	1.7	3	2.5

Appendix I (con't)

	1969 - 1973		1979 - 1983	
	Observed	Expected	Observed	Expected
Mashpee				
Males	1	0.3	3	1.0
Females	0	0.2	0	0.8
Middleborough				
Males	0	2.7	2	3.0
Females	1	2.3	3	2.8
Norwell				
Males	2	1.0	1	1.4
Females	2	0.8	0	1.3
Pembroke				
Males	1	1.5	2	1.8
Females	1	1.1	1	1.5
Plymouth				
Males	6	4.3	5	6.9
Females	5	3.6	7	5.9
Plympton				
Males	0	0.2	0	0.3
Females	0	0.1	0	0.2
Rochester				
Males	1	0.4	0	0.5
Females	0	0.2	0	0.4
Rockland				
Males	1	2.6	1	2.6
Females	4	2.1	4	2.3
Sandwich				
Males	0	1.0	2	1.9
Females	0	0.7	4	1.4
Scituate				
Males	1	2.5	3	3.0
Females	2	2.2	1	2.8
Wareham				
Males	2	2.7	4	4.4
Females	5	1.9	2	3.5
Whitman				
Males	2	2.2	2	2.2
Females	2	1.9	3	1.9

Appendix II

Observed and expected numbers of cancers of the blood forming organs diagnosed among the residents of selected towns in Southeastern Massachusetts, 1982-1984

	Observed		Expected	
	Males	Females	Males	Females
Barnstable	12	13	11.0	10.0
Bourne	6	2	3.8	3.5
Bridgewater	1	2	2.7	1.8
Carver	1	0	1.7	0.0
Duxbury	3	2	1.8	1.5
East Bridgewater	2	2	1.9	1.6
Halifax	1	1	1.2	0.6
Hanover	2	1	1.5	1.6
Hanson	1	0	1.1	0.0
Kingston	3	2	1.3	1.2
Marion	1	2	1.3	0.6
Marshfield	10	5	4.3	2.6

Appendix II (con't)

	Observed		Expected	
	Males	Females	Males	Females
Mashpee	0	0	0.0	0.0
Middleborough	2	3	3.7	2.9
Norwell	3	1	1.2	1.3
Pembroke	1	2	1.3	1.4
Plymouth	10	7	7.2	6.8
Plympton	0	0	0.0	0.0
Rochester	0	1	0.0	0.4
Rockland	1	1	2.8	2.2
Sandwich	3	0	2.3	0.0
Scituate	5	5	3.4	3.1
Wareham	4	2	3.5	2.7
Whitman	7	4	2.5	1.7